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G. ALLAN FROST . . . . Description of Fish otoliths from the tertiary formations of Atcheen, Northern Sumatra

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DESCRIPTION OF FISH OTOLITHS FROM THE TERTIARY FORMATIONS OF ATCHEEN, NORTHERN SUMATRA,

BY

G. ALLAN FROST, F.L.S., F.G.S., F.Z.S.

The material described consists of two large collections from the oil-fields of Atcheen (Sumatra), received from the Geological Survey of the Mining Bureau Bandoeng, Java, Dutch East India.

The slight value of fish remains for the decision of stratigraphical problems has been pointed out by WINDHAUSEN (1) and also proved in dealing with the fish fauna of Australia, notably the Triassic Hawkesbury system near Sydney.

It is therefore not proposed to attempt to define the exact stratigraphy of the formation involved, but simply to describe the faunal relationships of the zones and the horizons from which similar forms have already been described.

37 species are described belonging to 14 different families, there being 11 new forms among them.

Omitting new species, all the other forms have been described from European formations, with the exception of one from New Guinea and one from North America.

The presence of lower tertiary forms with those of a later date, can be explained by the known persistence of certain types, extending in some cases to recent species. Five of the otoliths figured are also to be found in the upper tertiaries of New Zealand.

The series of zones from which the otoliths are derived are stated to be neogene in the excellent geological maps published by the Mining Bureau and this is as definite as is desirable pending further investigations.

The preponderance of pliocene forms in the lower beds however confirms the placing of the whole series in the upper tertiaries.

(1) WINDHAUSEN, Amer. Journ. Science, Vol. 45, p. 4, 1918.

Possibly further investigations will show that they are entirely pliocene.

The zones are as follows in descending order ([1]), the number of species from each being given, and the age to which those already described have been referred.

Zones in descending order, and age of forms described.

1. Bruinkool-zone	1	Pliocene
	1	Miocene, oligocene & eocene
	1	Eocene
2. Operculina-zone	1	Miocene, oligocene & eocene
	1	Eocene
	1	Oligocene
	1	New species
3. Hoofdfossiel-zone	2	Pliocene
	1	Miocene
	2	Oligocene
	7	New species
4. Tufconglomeraat-zone	2	Pliocene
	1	Miocene
	2	Oligocene
	2	New species
5. Rotalia-zone	7	Pliocene
	4	Miocene
	2	Oligocene
	4	Eocene
	3	New species
6. Robulina-zone	4	Pliocene
	1	Miocene
7. Tusschenzandsteen	1	Pliocene
8. Grensklei	1	New species.

([1]) In accordance with the stratigraphy of Atjeh I, described in Jaarboek van het Mijnwezen 1917, Verhandelingen, deel I.

Zones in descending order.	Chart showing occurence of species.									Already described from				
	Bruinkool-zone.	Operculina-zone.	Hoofdfossiel-zone.	Tufconglomeraat-zone.	Rotalia-zone.	Robulina-zone.	Tusschenzandsteen.	Grensklei.	Sp. n.	Pliocene.	Miocene.	Oligocene.	Eocene.	
Fig. 1		•	•	•	•							•		1
2				•								•		2
3	•		•		•								•	3
4					•						•	•		4
5				•	•						•			5
6	•	•									•	•	•	6
7								•	•					7
8					•								•	8
9			•						•					9
10		•											•	10
11	•												•	11
12					•								•	12
13					•					•				13
14						•				•				14
15						•				•				15
16			•								•			16
17		•							•					17
18					•						•			18
19	•		•		•					•				19
20					•									20
21			•		•					•				21
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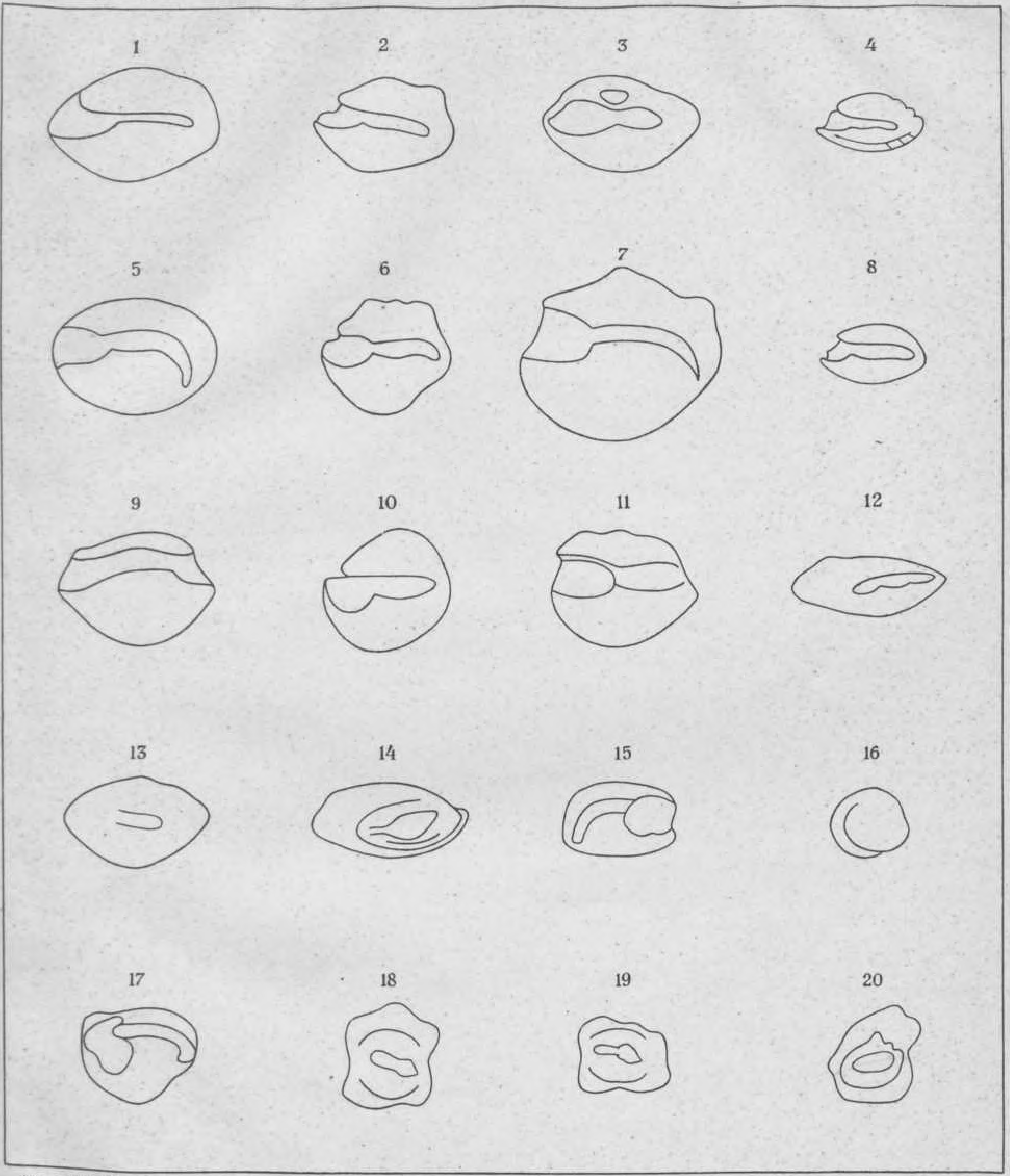
26				•					•					26
27			•						•					27
28				•	•	•				•				28
29			•	•	•	•	•			•				29
30			•							•				30
31				•	•						•			31
32						•				•	•			32
33				•	•							•		33
34				•	•				•					34
35				•					•					35
36			•						•					36
37			•						•					37
									11	20	10	9	9	

PLATE I.

LIST OF SPECIES DESCRIBED.

		Mag.
Serranidae.		
Fig. 1.	*O.* (Percidarum) *aff. plebejus* KOKEN	7½ × 1
2.	*O.* „ *plebejus* KOKEN	7 × 1
3.	*O.* (Apogoninarum) *Boulei* PRIEM	6½ × 1
4.	*O.* (Serranus) *Noetlingi* KOKEN	9 × 1
Sparidae.		
5.	*O.* (Sparidarum) *vöslauensis* SCHUBERT	5½ × 1
6.	„ „ *gregarius* KOKEN	7 × 1
7.	„ „ *crescens* sp. n.	6 × 1
8.	„ (Dentex) *aff. tardinensis* LERICHE	6 × 1
Berycidae.		
9.	*O.* (Berycidarum) *atjehensis* sp. n.	5 × 1
10.	*O.* (Monocentris) *Lemoinei* PRIEM	5 × 1
11.	„ „ „ *var. angulatus* sp. n.	5 × 1
Trachinidae.		
12.	*O.* (Trachinus) *seelandicus* KOKEN	12½ × 1
Ophidiidae.		
13.	*O.* (Ophidium) *Pantanellii* BASS & SCHUBERT	7½ × 1
14.	„ „ *magnus* BASS	4 × 1
Sciaenidae.		
15.	*O.* (Umbrinus) *plenus* SCHUBERT	6½ × 1
16.	*O.* (Sciaenidarum) *aff. subgemma* SCHUBERT	7 × 1
17.	*O.* (Micropogon) *distinctus* sp. n.	3 × 1
Gobiidae.		
18.	*O.* (Gobius) *vicinalis* KOKEN	10 × 1
19.	„ „ *aff.* „ BASSOLI	5 × 1
20.	„ „ *obliquus* sp. n.	8 × 1



Top. Inr. Bat. 1924.

Fish otoliths of Atcheen

PLATE II.

Macruridae.

		Mag.
Fig. 21.	*O.* (Macrurus) *Trolli* Schubert	6 × 1
22.	„ „ *Toulai* „	5 × 1
23.	„ „ *gracilis* „	10 × 1
24.	„ „ *aff. praecursor* Priem	7½ × 1

Clupeidae.

25.	*O.* (Engraulidarum) *erectus* sp. n.	6 × 1
26.	*O.* (Clupeidarum) *dilatus* sp. n.	6 × 1
27.	*O.* (Clupeidarum) *parvulus* sp. n.	6 × 1

Scopelidae.

28.	*O.* (Scopelus) *sulcatus* Prochazka	4½ × 1
29.	„ „ *pulcher* „	4½ × 1
30.	„ „ *fragilis* „	7 × 1
31.	„ „ *circularis* sp. n.	8 × 1
32.	„ „ *papuensis* Schubert	7 × 1

Soleidae.

33.	*O.* (Solea) *glaber* Koken	11 × 1
34.	„ „ *angulatus* sp. n.	7½ × 1

Cepolidae.

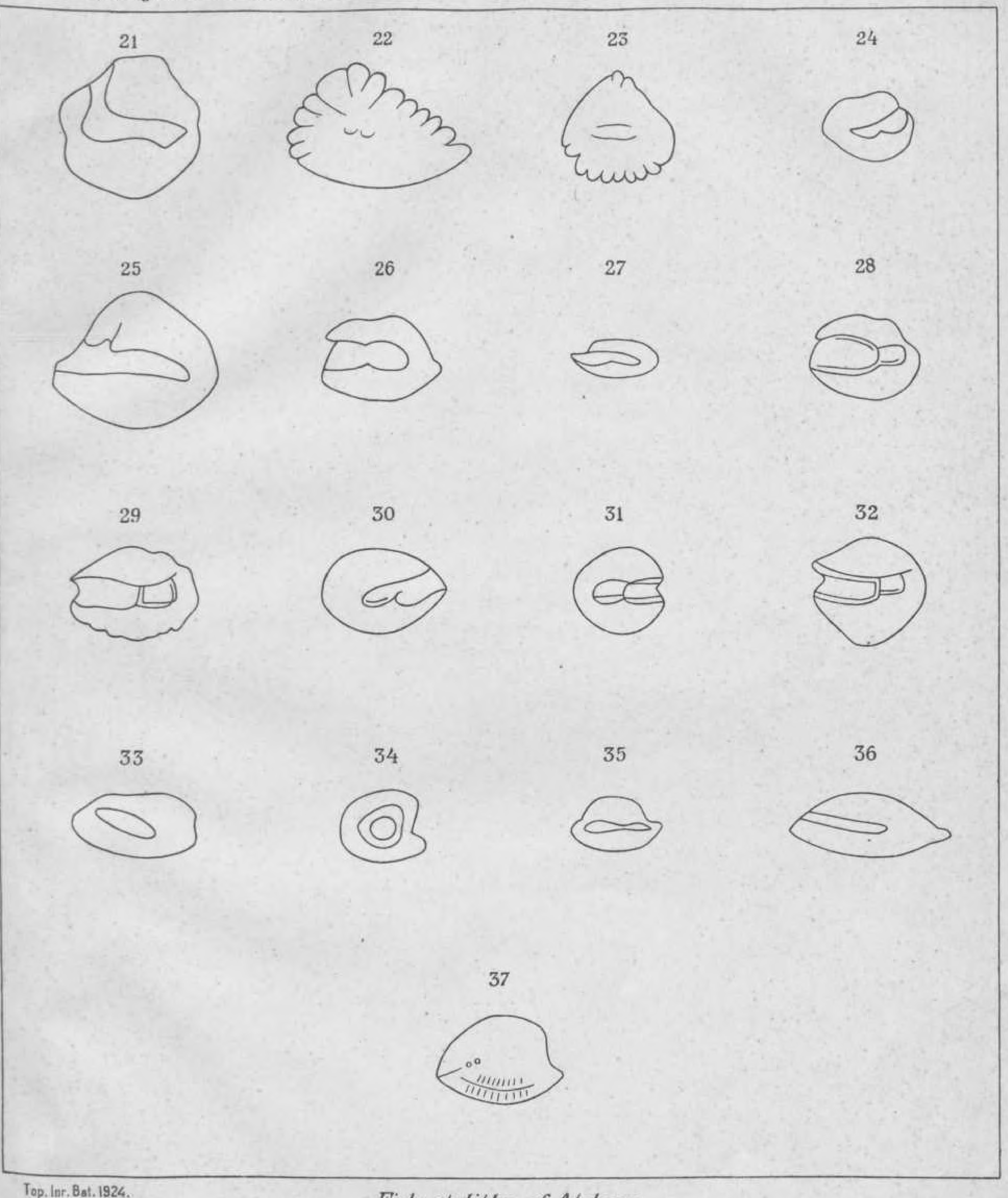
35.	*O.* (Cepola) *oriens* sp. n.	5 × 1

Pleuronectidae.

36.	*O.* (Pleuronectes) *elongatus* sp. n.	6 × 1

Siluridae.

37.	*O.* (Arius) *tenius* sp. n.	4 × 1



Top. Inr. Bat. 1924.

Fish otoliths of Atcheen

Otolithus (Percidarum) aff. plebejus KOKEN. Plate 1. Fig. 1.

Dimensions. 4 × 3 m.m.

Diagnosis. Ovate, outerside slightly concave with radiating furrows, innerside convex; front pointed, dorsal rim domed, posterior rim rounded, ventral rim keeled with forward inclination. Rostrum, but no notch or antirostrum. Sulcus open on front of otolith, ostium depressed, cauda straight, with slight downward curve at termination, cauda does not reach posterior rim.

Remarks. This otolith has a general resemblance to *O.* (Percidarum) *plebejus* decribed by KOKEN [1]) from the middle oligocene of Waldbockelheim, but the dorsal rim is more domed and not serrated, and the cauda not so curved at its termination. It is undoubtedly related to *O. (Percidarum) plebejus* but differs in the above particulars. I have therefore called this form *Otolithus* (Percidarum) *aff. plebejus* KOKEN.

Occurrence. Rotalia-zone, Aloeë Nie (Peusangan) Leubö Atjeh (Kr. Peusangan) and other place.
Tufconglomeraat-zone, Anak Oeweuë Gadjah (Peusangan).
Hoofdfossiel-zone, Kroeëng Goentji (Sawang).
Operculina-zone, Anak Minjak Sapi (Sawang).

Age. Upper Tertiary (Neogene).

Otolithus (Percidarum) plebejus KOKEN. Plate 1. Fig. 2.

Dimensions. 2 × 1½ m.m.

Diagnosis. Ovate, outerside flat, innerside sligthly convex, dorsal rim domed with posterior depression, ventral rim keeled, posterior rim rounded, front with rostrum, slight antirostrum and notch. Sulcus, ostium wide, open on front, cauda gently curved, does not reach posterior rim.

Remarks. Described by KOKEN ([1]) from the middle oligocene of Waldbockelheim.

Occurrence. Scarce.
Tufconglomeraat-zone, Anak Oeweuë Gadjah (Peusangan).
Upper tertiary (Neogene).

(1) E. KOKEN, Zeit. d. Deut. Geol. Ges. XLIII p. 77, Berlin 1891.

Otolithus (Apogoninarum) Boulei PRIEM. Plate I, Fig. 3.

Dimensions. 4 × 3 m.m.

Diagnosis. Ovate, bi-convex, front rounded, slight indentation above ostium; dorsal rim domed, ventral rim curved with slight serrations towards rear, posterior rim rounded, rear of otolith narrower than front.

Sulcus straight, ostium wide, extending to frontal rim, cauda smaller than ostium does not approach posterior rim. Above sulcus there is an ovate depression distinctive of this species.

Remarks. This form very numerous in the upper eocene and similar to the otoliths of living species is a persistent type and therefore is of little value for stratigraphical purposes. Described by SCHUBERT (1) in 1915 as *Otolithus* (Monocentris) *bellovacinus* from the upper eocene of Barton, Hampshire, and later by SHEPHERD (2) as *Apogon eocenicus*, it is undoubtedly the same as figured by PRIEM (3) in 1906 from the eocene of Chaussy and named by him *Otolithus* (Apogoninarum) *Boulei*.

Occurrence. Rare.

Rotalia-zone,	Leubö Atjeh (Kroeëng Peusangan). Anak Mata Ieë (Peusangan) Aloeë Papeuën (Peusangan).
Hoofdfossiel-zone,	Aloeë Tabib (Peusangan). Anak Boegeng Tho (Peusangan). Aloeë Djiedjieb (Peusangan).
Bruinkool-zone,	Aloeë Minjeu.

Age. Upper Tertiary (Neogene).

Otolithus (Serranus) Noetlingi KOKEN. Plate I, Fig. 4.

Dimensions. 2 × 1½ m.m.

Diagnosis. Ovate, outerside convex, innerside convex with furrows on rear of otolith on dorsal and ventral rims.

Slight rostrum, no notch or antirostrum.

Sulcus straight, front of ostium protruding.

(1) R. SCHUBERT, Jahrb. K. K. Geol, Rchs.-Anst. 65 Taf. VII 1915.
(2) C. E. SHEPHERD, Bull. Soc. geol. de France XXII pl. vii, 1922
(3) F. PRIEM, Bull. Soc. geol. de France vol. vi. p. 265, 1906.

Remarks. Described by KOKEN (1) from the upper oligocene of Sternberger Gestein, also by PRIEM (2) from the miocene of Leognan, S. W. France.

Occurrence. 2 examples.
Rotalia-zone, Anak Oeweuë Gadjah (Peudada).

Age. Upper Tertiary (Neogene).

Otolithus (Sparidarum) vöslauensis SCHUBERT. Plate I, Fig. 5.

Dimensions. 5 × 3½ m.m.

Diagnosis. Elliptical, outerside concave, slightly furrowed, innerside convex. Front rounded, dorsal, ventral and posterior rims rounded. No rostrum, antirostrum or notch.
Sulcus, ostium wide, cauda wide and heavily curved, termination nearly extending to ventral rim.

Remarks. This example resembles *O.* (Percidarum) *aequalis* KOKEN *var. burdigalensis* described by PRIEM (3) from the miocene of Clermont, S. W. France, but differs in the shape of the ostium, which in the species now described is less depressed, the cauda also is more angular and the curve more accentuated.
Although a little more rounded in front there is no difficulty in referring it to *Otolithus* (Sparidarum) *vöslauensis* described by SCHUBERT (4) from the miocene of Vöslau in Austria-Hungary.

Occurrence. Two examples only.
Rotalia-zone, Anak Mata Ieë (Peusangan).
Tufconglomeraat-zone, Anak Oeweuë (Peudada).

Age. Upper Tertiary (Neogene).

Otolithus (Sparidarum) gregarius KOKEN. Plate I. Fig. 6.

Dimensions. 3 × 3 m.m.

(1) E. KOKEN, Zeit. d. Deut. Geol. Ges. XLIII p. 77, Berlin 1891.
(2) F. PRIEM, Bull. Soc. geol. de France XLV. 1914.
(3) F. PRIEM, Bull. Soc. geol. France 4° série T. XIV, 1914
(4) R. SCHUBERT, Jahrb. K. K. Geol. Rchs.-Anst. 56 p. 638 Wien 1906.

Diagnosis. Circular, outerside flat, innerside convex.
Dorsal rim with two indentations, ventral rim keeled, posterior rim rounded, front rounded. No rostrum, slight antirostrum with notch below.
Sulcus, ostium wide, cauda wide and straight curved at termination, does not reach posterior rim.

Remarks. First described by KOKEN (1) from the upper oligocene of Sternberger Gestein, numerous examples from the miocene of S. W. France have been figured by PRIEM (2), others have been noted by SCHUBERT (3) from the eocene of Barton, Hampshire.

Occurrence. 4 Examples.
Operculina-zone, Alloeë Kala (Sawang).
Bruinkool-zone, Al. Minjeu.

Age. Upper Tertiary (Neogene).

Otolithus (Sparidarum) crescens sp. n. Plate I. Fig. 7.

Dimensions. 6 × 4¼ m.m.

Diagnosis. Ovate, outerside concave, innerside convex, dorsal rim angular, posterior rim with angle at junction with dorsal rim, ventral rim curved.
Sulcus opens widely on frontal rim, ostium wide, cauda narrow and sickle-shape.

Remarks. The crescentic form of the cauda is a marked feature, to be seen also in *O. Percidarum aequalis, var. burdigalensis*, described by PRIEM (4) from the miocene of Labrede Gironde, and also in *O. Sparidarum vöslauensis*, SCHUBERT (5) from the miocene of Austria Hungary but in both these cases the cauda is coarser than in the example described. In general contour the otolith resembles that of the recent species *Pagrus cardinalis* from Japan, and also examples from the

(1) E. KOKEN, Zeitsch. d. Deut. Geol. Ges. XLIII p. 77 Berlin 1891.
(2) F. PRIEM, Bull. Soc. geol. de France XIV, 1914.
(3) R. SCHUBERT, Jahrbuch der K. K. Geol. Rchs.-Anst. Bd. 65, Taf. vii. 1915.
(4) F. PRIEM, Bull. Soc. geol. de France 4 sér. t. XI p. 39 1911.
(5) R. SCHUBERT, Jahrb. der K. K. Geol. Rchs.-Anst. Bd. 56 p. 623 Wien 1906.

eocene of Barton, Hampshire which have been erroneously referred by SCHUBERT [1] to *O. Pagellus gregarius* KOKEN, and which should be designated *O. Pagrus eocenicus*, but in both these cases the cauda is straighter. This is a new and distinctive sparoid otolith which I have named *Otolithus* (Sparidarum) *crescens* sp. n.

Occurrence. Scarce. Grensklei, Anak Bateë Poetih (Peusangan). and Operculina-zone, Aloeë Kota Kanan (Peudada).

Age. Upper tertiary (Neogene).

Otolithus (Dentex) aff. tardinensis LERICHE. Plate I. Fig. 8.

Dimensions. 3 × 2 m.m.

Diagnosis. Elliptical, outerside convex, innerside convex.
Dorsal and posterior rims in one curve, ventral rim gently curved, front angular.
Rostrum slight with notch above, no antirostrum.
Sulcus oblique, ostium small, cauda wide does not reach posterior rim.

Remarks. This otolith resembles *Otolithus* (Dentex) *tardinensis* described by LERICHE [2] from the eocene of Pourcy, Marne, but is less elongated and the dorsal rim is more domed. The small ostium and wide oblique cauda are the same however, and I therefore refer this form to *Otolithus* (Dentex) *aff. tardinensis* LERICHE.

Occurrence. Single example.
Rotalia-zone, Anak Oeweuë Gadjah (Peudada).

Age. Upper tertiary (Neogene).

Otolithus (Berycidarum) atjehensis n. sp. Plate I. Fig. 9.

Dimensions. 5 × 3½ m.m.

Diagnosis. Shape ovate, outerside concave, rugose, innerside convex, dorsal, rim curved, depressed behind, ventral rim keeled, front of otolith obtuse, posterior rim angular.

(1) R. SCHUBERT, Jahrb. der K. K. Rchs.-Anst. Bd. LXV Taf. VII Wien 1915.
(2) M. LERICHE, Ann. geol. du Nord. XXXVII, pl. VI, Lille 1908.

Sulcus sigmoidal, wide, ostium short, cauda curved and opening widely on posterior rim.

Remarks. This otolith resembles those of the living *Beryx splendens* in its deep keel and in the shape of the ventral and posterior rims, it varies in the sulcus which although sigmoidal as in Beryx is different, the ostium being short, not as depressed and opening on the frontal rim.

The general resemblance however can be seen on comparing the example with an otolith of the living Beryx. It is a new species and I have named it *Otolithus* (Berycidarum) *atjehensis* n. sp.

Occurrence. One example.
Hoofdfossiel-zone, Anak Simpang Bateë Masdjid.

Age. Upper tertiariy (Neogene).

Otolithus (Monocentris) Lemoinei PRIEM. Plate I. Fig. 10.

Dimensions. 2 $\times$ 2 m.m.

Diagnosis. Shape circular, biconvex, dorsal rim domed, frontal and posterior rims rounded, ventral rim keeled.

Sulcus wide, ostium deep, cauda short and spread, terminating some distance from posterior rim.

Remarks. Described by PRIEM [1] from the eocene of the Paris basin and by LERICHE [2] from the eocene of Reims.

Occurrence. Single example.
Operculina-zone, Aloeë Kala (Sawang).

Age. Upper tertiary (Neogene).

Otolithus (Monocentris) Lemoinei PRIEM var. angulatus nov. var. PlateI. Fig. 11.

Dimensions. 5 $\times$ 3 m.m.

Diagnosis. Shape circular, outerside concave, innerside convex, dorsal rim with two indentations, frontal rim rounded, ventral rim keeled, posterior rim angular.

(1) F. PRIEM, Bull Soc. geol. de France T. VI, p. 265 1906.
(2) M. LERICHE, Ann. Soc. geol. du Nord XXXVII pl. XI Lille 1908.

Sulcus wide, ostium deep, opening on frontal rim, cauda narrower than ostium, uptilted, and open on posterior rim.

Remarks. The general conformation and the bold sulcus are very similar to those of *Otolithus* (Monocentris) *Lemoinei* described by PRIEM (1) from the eocene of France also figured by LERICHE (2) from the eocene near Reims, but the posterior rim has an angular projection whereas *O.* (Monocentris) *Lemoinei* is rounded behind.
I have therefore called this from:
Otolithus (Monocentris) *Lemoinei, n. var. angulatus.*

Occurrence. Single example.
Rotalia-zone, Aloeë Empang Mana (Peusangan).

Age. Upper tertiary (Neogene).

Otolithus (Trachinus) seelandicus KOKEN. Plate I. Fig. 12.

Dimensions. 2 × 1 m.m.

Occurrence. Shape ovate, bi-convex.
Dorsal and ventral rims curved, meeting in front at an acute angle, posterior rim rounded.
Sulcus oblique, ostium longer than cauda, approaches front of dorsal rim without cutting it, cauda more oblique than ostium, terminates a considerable distance from the posterior rim.

Remarks. Described by KOKEN (3) from the paleogene of Copenhagen.

Occurrence. Rotalia-zone, Lb. Atjeh, Kr. Peusangan.

Age. Upper tertiary (Neogene).

Otolithus (Ophidium) Pantanellii BASS. & SCH. Plate I. Fig. 13.

Dimensions. 3½ × 2 m.m.

Diagnosis. Shape ovate, bi-convex.
Dorsal and ventral rims, plain, curved, meeting frontally and posteriorly forming fairly acute angles.
Sulcus straight, cauda terminates some distance from posterior angle.

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(1) F. PRIEM, Bull. Soc. geol. de France T. VI p. 265 1906.
(2) M. LERICHE, Ann. Soc. geol. du Nord XXXVII, pl. VI, Lille 1908.
(3) E. KOKEN, Zeit. d. Deut. Geol. Ges. XLIII, p. 113 Berlin, 1891.

Remarks. Described by BASSOLI [1] from the pliocene of Monte Gibio, and the miocene of Pantano, Italy. This otolith also occurs freely in the upper tertiaries of New Zealand.

Occurrence. Rotalia-zone.
Anak Oeweuë Gadjah (Peudada).
Aloeë Roerih (Peusangan).
Ma. Aloeë Oeleuë Kebeuë.
Lb. Atjeh, Kr. Peusangan.

Age. Upper tertiary (Neogene).

Otolithus (Ophidium) magnus BASSOLI. Plate I. Fig. 14.

Dimensions. 7 × 4 m.m.

Diagnosis. Shape ovate, outerside flat with ridge on ventral part, innerside flat.
Dorsal and ventral rims curved, frontal and posterior rims rounded.
Sulcus completely enclosed, ostium shallow, ovate, cauda, a narrow short groove, ridges surround the sulcus except in front.

Remarks. Described by BASSOLI [2] from the pliocene of Monte Gibio, Italy.

Occurrence. One example.
Robulinaklei, Anak Aloeë G. Asa (Peusangan).

Age. Upper tertiary (Neogene).

Otolithus (Umbrina) plenus SCHUBERT. Plate I. Fig. 15.

Dimensions. 3 × 2 m.m.

Diagnosis. Shape oblong, bi-convex.
Outerside umbonate on dorsal and posterior parts, innerside flat.
Sulcus wide, ostium flat and dilated, cauda heavily curved terminating close to ventral rim.

(1) BASSOLI, Riv. Ital. di Paleont. Anno XII page 45, Perugia 1906.
(2) G. G. BASSOLI, Riv. Ital. di Paleont. Anno XII Perugia 1906.

Remarks. This is a typically sciaenoid form and has been described by SCHUBERT [1] from the pliocene of Brunn and Gebirge in Austria Hungary.

Occurrence. One example.
Robulinaklei, Anak Aloeë E. Asa (Peusangan).

Age. Upper tertiary (Neogene).

Otolithus (Sciaenidarum) aff. subgemma SCHUBERT Plate I. Fig 16.

Dimensions. 2 × 2 m.m.

Diagnosis. Circular, biconvex cauda encircles half of the outer rim.

Remarks. This small example has been subjected to attrition, but the shape has not been impaired and the groove of the cauda is distinct.
It is evidently the same species described by PRIEM [2] from the miocene of Léognan, S. W. France.

Occurrence. Single example.
Hoofdfossiel-zone of A. Seudjeungkai (Nisam).

Age. Upper tertiary (Neogene).

Otolithus (Micropogon) distinctus sp. n. Plate I Fig. 17.

Dimensions. 7 × 6 m.m.

Diagnosis. Shape circular, outerside domed, flattenning towards circumference, innerside slightly convex.
Dorsal rim rounded small depression in front, ventral rim keeled, posterior rim rounded, slight angle at junction with ventral rim, frontal rim rounded with slight prominence dorsally.
Sulcus with shallow large spread ostium, cauda deep termination club-shaped does not cut into posterior rim.

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(1) R. SCHUBERT, Jahrb. der K. K. Geol. Rchs.-Anst. 51 p. 301, Wien 1901.
(2) E. PRIEM, Bull. Soc. geol. de France T. XVI p. 272 1914.

Remarks. Closely resembling the otolith of the recent species *Micropogon furincri* in general outline, and in the club-shaped cauda, this example differs in the very sharp edge running entirely round it. Unlike any fossil sciaenoid otolith yet described, I have named it *Otolithus* (Micropogon) *distinctus* **sp. n.**

Occurrence. Single example.
Operculina-zone, Al. Kala (Sawang).

Age. Upper tertiary (Neogene).

Otolihus (Gobius) vicinalis KOKEN. Plate I. Fig. 18.

Dimensions. 1½ × 1¼ m.m.

Diagnosis. Shape roughly pentagonal, outerside furrowed, innerside flat. Dorsal rim domed, posterior, frontal and ventral rims concave.
Sulcus, centre of otolith with groove surrounding it.
Ostium wide and angular, cauda short and rounded.

Remarks. This otolith resembles that of the living species *Gobius niger* and is similar to that described by SCHUBERT (1) from the miocene of Vöslau in Austria Hungary and referred by him to *O.* (Gobius) *vicinalis* KOKEN.

Occurrence. Rotalia-zone, Aloeë Oedeuëng (Peusangan).
Hoofdfossiel-zone, Kr. Goentji (Sawang).
Grensklei, Aloeë Bateë Poetih (Peusangan).

Age. Upper tertiary (Neogene).

Otolithus (Gobius) aff. vicinalis, BASSOLI. Plate I. Fig. 19.

Dimensions. 3 × 2¼ m.m.

Diagnosis. Shape irregular, outerside convex with furrows running from dorsal rim to a ventral umbo. Innerside flat with circular groove round sulcus, above which is an ovate depression.
Sulcus enclosed, ostium broad and depressed, cauda small with rounded end.

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(1) R. SCHUBERT, Jahrb. der K. K. Geol. Rchs.-Anst. LVI p. 623, Wien 1906.

Remarks.	This form is near that of the living species *Gobius quadrimaculatus*, and has been described by BASSOLI (1) from the pliocene of Monte Gibio as *Otolithus* (Gobius) *aff. vicinalis.*
Occurrence.	Rotalia-zone, Anak Boegeng Tho (Peudada). Al. Anak Lhong. Lb. Atjeh (Kr. Peusangan). Hoofdfossiel-zone, Anak Oeweuë Gadjah (Peusangan). Aloeë Djiedjieb (Peusangan). Bruinkool-zone, Aloeë Minjeu.
Age.	Upper tertiary (Neogene).

Otolithus (Gobius) obliquus sp. n. Plate I. Fig. 20.

Dimensions.	2½ × 2 m.m.
Diagnosis.	Shape irregular, outerside convex, innerside flat. Dorsal rim, with median indentation, projecting forward, ventral rim curved, posterior rim with slight median angle, frontal rim concave. Sulcus with groove entirely surrounding it, no distinct separation of ostium and cauda.
Remarks.	The sulcus in this species resembles that of *Otolithus* (Gobius) *intimus* described by SCHUBERT (2) from the miocene of Vöslau, there is however an extension of the dorsal rim forwardly and upwardly which gives an unbalanced appearance to the otolith unlike any yet described. In *O.* (Gonius) *pretiosus* PROCH. also described by SCHUBERT from Vöslau there is a frontal projection of the dorsal part of the otolith but this has no upward direction as in the species now described. I have therefore called this species *Otolithus* (Gobius) *obliquus* sp. n.
Occurrence.	Rotalia-zone, Kr. Tjoet (Peusangan). Aloeë Tho (Peusangan).
Age.	Upper tertiary (Neogene).

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(1) G. G. BASSOLI, Riv. Ital. di Paleont. Anna XII, p. 54, Perugia 1906.
(2) R. SCHUBERT, Jahrb. der K. K. Geol. Bd. 56 p. 623 1906.

Otolithus (Macrurus) Trolli SCHUBERT. Plate II. Fig. 21.

Dimensions. 4 × 4 m.m.

Diagnosis. Shape circular bi-convex, outerside furrowed, innerside smooth. Dorsal rim angular, ventral, frontal and posterior rims rounded. Sulcus communicates by groove with dorsal rim, ostium rounded, cauda with angular termination.

Remarks. Described by BASSOLI (1) from the pliocene of Monte Gibio, Italy. These forms occur freely in the Rotalia-zone to a smaller extent in the Hoofdfossiel-zone and are absent from the rest of the series.

Occurrence. Common in Rotalia-zone, example from
Aloeë Oeweuë Keubeuë (Peusangan).
Kr. Teumor (Peusangan).
Anak Oeweuë Gadjah (Peudada).
Aloeë Bateë Kr. Peusangan.
Lb. Atjeh, Kr. Peusangan.
Ma. Aloeë Oeleuë Keubeuë.
Anak Boegeng Tho (Peudada).
Aloeë Roerih (Peusangan).
Hoofdfossiel-zone, A. Paja Geleuntah.
Weg Awé Gentah (Peusangan).
Anak Aloeë Teumoë.
None in intervening Tufconglomeraat-zone.

Age. Upper tertiary (Neogene).

Otolithus (Macrurus) Toulai SCHUBERT. Plate II. Fig. 22.

Dimensions. 6 × 4½ m.m.

Diagnosis. Shape triangular, outerside has centrale ridge with furrows radiating to dorsal and frontal rims. Innerside flat.
Sulcus straight, does not cut frontal or posterior rims, ostium and cauda equal.

Remarks. Described by SCHUBERT (2) from the tertiaries of Austria—Hungary, and by BASSOLI (3) from the pliocene of Monte Gibio, Italy, it also occurs freely in the Oamaru series of New Zealand.

(1) G. G. BASSOLI, Riv. Ital. di Paleont. Anno XII p. 42, Perugia 1906.
(2) R. SCHUBERT, Jahrb. der K. K. Geol. Rchs.-Anst. 55 p. 513 Wien 1905.
(3) G. G. BASSOLI, Riv. Ital. Paleont. Anno XII p. 42 Perugia 1906.

Occurrence. Single example.
Rotalia-zone, Aloeë Oeweuë Keubeuë (Peusangan).

Age. Upper tertiary (Neogene).

Otolithus (Macrurus) gracilis SCHUBERT. Plate II, fig. 23.

Dimensions. 2 × 1½ m.m.

Diagnosis. Shape, conchoidal, outerside convex with radiating furrows forming serrations on dorsal and ventral rims.
Innerside flat.
Sulcus straight with depression above.

Remarks. Described by SCHUBERT (1) from the tertiaries of Austria-Hungary, and by BASSOLI (2) from the pliocene of Monte Gibio, Italy, it also occurs in the Oamaru series of New Zealand.

Occurrence. Single example.
Rotalia-zone, Aloeë Oeweuë Keubeuë (Peusangan).

Age. Upper tertiary (Neogene).

Otolithus (Marcurus) aff. praecursor PRIEM Plate II, fig. 24

Dimensions. 2 × 1½ m.m.

Diagnosis. Shape ovate, outerside flat with slight furrows on edges.
Innerside flat.
Sulcus enclosed, ostium slightly larger than cauda.

Remarks. Described by PRIEM (3) from the miocene of Clermont, S.W. France.

Occurrence. Single example.
Rotalia-zone, Aloeë Roerih (Peusangan).

Age. Upper tertiary (Neogene).

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(1) R. SCHUBERT, Jahrb. der K. K. Geol. Rchs.-Anst. 55 p. 513, Wien 1905.
(2) G. G. BASSOLI, Riv. Ital. Paleont. Anno XII p. 42, Perugia 1906.
(3) F. PRIEM, Bull. Soc. geol. de France XIV 1914.

Otolithus (Engraulidarum) erectus n. sp. Plate II fig. 25.

Dimensions. $4\frac{1}{2} \times 3$ m.m.

Diagnosis. Shape irregular, outerside convex, smooth; innerside flat.
Dorsal rim domed, falling away above rostrum, ventral rim curved, slight at juncture with posterior rim.
Rostrum blunt, no antirostrum or notch.
Sulcus wide, straight, ostium open on frontal rim, termination of cauda pointed with downard inclination, end of cauda some distance from posterior rim.

Remarks. Not before described this form combines the features of the otoliths of certain of the living Engraulidae.
The sulcus is similar to that of *Engraulis setirostris* a South African fish, the high domed dorsal rim with its precipitous front is typical of *Coilia dussumieri* and *Setipinna breviceps,* both of the Dutch East Indies, while the blunt rostrum half covered by the ostium, is present in the otoliths of all three species.
I have therefore named this otolith, *Otolithus* (Eugraulidarum) *erectus* n. sp.

Occurrence. Hoöfdfossiel-zone, Aloeë Bateë Plang (Nisam).
" Kr. Goentji (Sawang).

Age. Upper tertiary (Neogene).

Otolithus (Clupeidarum) dilatus n. sp. Plate II. Fig. 26.

Dimensions. $3\frac{1}{2} \times 2\frac{1}{2}$ m.m.

Diagnosis. Shape ovate, outerside flat, innerside convex, dorsal rim straight, posterior rim with angle, ventral rim curved, frontal rim straight. No rostrum, antirostrum or notch.
Sulcus very wide, straight, ostium open on frontal rim, cauda bulging and longer than ostium, terminating some distance from posterior rim.

Remarks. A new form resembling the otoliths of the living species *Chirocentrus dorab*, from the Dutch East Indies.
The contours agree with the exception of the frontal rim,

In Chirocentrus there is a notch with rostrum and antirostrum but in the species described the ostium presents a straight edge without notch forming a square front to the otolith. The lower part of the otolith in Chirocentrus is also rather more produced forwardly, that of the fossil form being truncated. With regard to the sulcus the two forms are very similar, I have called this species *Otolithus* (Clupeidarum) *dilatus* n. sp.

Occurrence. Two examples.
Tufconglomeraat-zone, Al. Leuhob.

Age. Upper tertiary (Neogene).

O t o l i t h u s (Clupeidarum) p a r v u l u s sp. n. Plate II. Fig. 27.

Dimensions. $2\frac{1}{2} \times 1$ m.m.

Diagnosis. Shape ovate, outerside flat, innerside convex, dorsal rim curved, posterior rim rounded, front with rostrum, no antirostrum or notch.
Sulcus broad with angle between ostium and cauda, which are equal in length. Cauda terminating a considerable distance from posterior rim.

Remarks. Of about the same proportions as *O.* (Clupea) *testis* described ky KOKEN [1] from the upper oligocene of Sternberger Gestein, the front of the otolith lacks the deep notch and antirostrum of this species.

Occurrence. Single example.
Hoofdfossiel zone, Tjot Lhong (Sawang).

Age. Upper tertiary, (Neogene).

O t o l i t h u s (Scapelus) s u l c a t u s PROCHAZKA. Plate II, fig. 28.

Dimensions. 4×3 m.m.

Diagnosis. Shape ovate, outerside flat, innerside convex.
Dorsal, ventral and posterior rims curved without serrations, frontal rim with slight notch below antirostrum.
Sulcus wide and straight, ostium longer than cauda.

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(1) E. KOKEN, Zeit. d. Deut. Geol. Ges. Bd. XLIII, Taf. I Berlin 1891.

Remarks. First described by PROCHAZKA (1) in 1893 as Berycidarum. This error was pointed out by PRIEM (2) in 1911, the sulcus being distinctly scopeloid and in no way resembling those of the Berycidae. This from has been described by BASSOLI (3) from the pliocene of Monte Gibio near Modena Italy. It also occurs in the Oamaru series of the New Zealand tertiaries.

Occurrence. Common, Robulinaklei, Aloeë Batoeë Tjante (Peudada).
Rotalia-zone, Anak Oeweuë Gadjah (Peudada).
Tufconglomeraat-zone, Anak Oeweuë Gadjah (Peudada).

Age. Upper tertiary (Neogene).

Otolithus (Scopelus) **pulcher** PROCHAZKA. Plate II Fig. 29.

Dimensions. 5 × 3½ m.m.

Diagnosis. Shape ovate, and longer than *O.* (Scopelus) *sulcatus*. Outerside slightly convex with faint serrations on ventral rim, innerside convex. Dorsal rim curved with some indentations ventral rim curved, posterior rim rounded. Rostrum and antirostrum equal; notch in middel of frontal rim.
Sulcus not so wide as in *O.* (Scopelus) *sulcatus* and more curved, ostium open on frontal rim and longer than cauda.
Cauda curved upwards square in shape, near line being parallel with posterior rim of otolith.

Remarks. First described by PROCHAZKA (4) as Berycidarum and later by SCHUBERT (5) from the tertiary of Austria Hungary. BASSOLI (6) also figures it from the pliocene of Monte Gibio. Italy where 800 examples were recovered, he also notes an example from the miocene. PRIEM (7) who first gave the correct genus, described the finding of it in the pliocene of Aleria, Corsica.

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(1) PROCHAZKA, Sitzungsber. d. bohm. Franz Joseph Akad. in Prag XXVI, p. 80 1893.
(2) F. PRIEM, Bull. Soc. geol. de France tome XI 1911.
(3) G. G. BASSOLI, Riv. Ital. di Paleont. Anno XII, Perugia 1906.
(4) PROCHAZKA, Sitzungsber. d. bohm. Franz Joseph Akad. in Prag. XXVI, p. 80, 1893
(5) R. SCHUBERT, Jahrb. der K. K. Geol. Rchs.-Anst. XVII, Wien 1905.
(6) G. G. BASSOLI, Riv. Ital. di Peleont. Anno XII, p, 49 Perugia 1906.
(7) F. PRIEM, Bull. Soc. geol. de France tome XI, 1911.

Occurrence. Common, Robulinaklei, Aloeë Bateë Tjante (Pendata).
Rotalia-zone, Aloeë Roerih (Peusangan).
Tufconglomeraat-zone, Anak Oeweuë Gadjah (Peudada).
Hoofdfossiel-zone, Anak Oeweuë Gadjah (Peudada).
Tusschenzandsteen, Aloeë Bateë Bido (Peusangan).
and other places in these zones.

Age. Upper tertiary (Neogene).

Otolithus (Scopelus) fragilis PROCHAZKA (1) Plate II. Fig. 30.

Dimensions. 3 × 2 m.m.

Diagnosis. Shape ovate, outerside convex, innerside flat.
Dorsal and ventral rims curved meeting in front.
Front pointed, posterior rim rounded.
Sulcus straight, ostium larger than cauda.

Remarks. Described by SCHUBERT (2) from the tertiaries of Austria-Hungary and by BASSOLI (3) from the pliocene of Ca di Roggio, Italy. This otolith is very thin and fragile, the example being broken in half when received.

Occurence. Single example.
Hoofdfossiel-zone, Anak Oeweuë Gadjah (Peudada).

Age. Upper tertiary (Neogene).

Otolithus (Scopelus) circularis n. sp. Plate II. Fig. 31.

Dimensions. 2 × 2 m.m.

Diagnosis. Shape circular, outerside convex with central umbo, and radiating furrows to outer rim, innerside flat.
Dorsal, ventral and posterior rims rounded, frontal rim with notch rostrum and antirostrum.
Sulcus straight, open on frontal rim, cauda narrower and shorter than ostium.

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(1) PROCHAZKA, Sitzungsber. d. böhm. Franz Joseph Akad. in Prag. XXVI Taf. III, fig. 11, 1893.
(2) R. SCHUBERT, Jahrb. der K K. Geol. Rchs.-Anst. XVII, Wien 1905.
(3) G. G. BASSOLI, Riv. Ital. di Paleont Anno XII p. 51, Perugia 1906.

Remarks. This new form of scopeloid otolith I have already described from the Oamaru (miocene) series at Target Gully, New Zealand in a paper read before the Otago Institute Nov. 1923.

Occurence. Scarce, 3 ex. from Rotalia-zone at
Aloeë Oeleuë Keubeuë (Peusangan).
Aloeë Papeën (Peusangan).
Anak Boegeng Tho (Peudada).

Age. Upper tertiary (Neogene).

Otolithus (Scopelus) papuensis SCHUBERT. Plate II, fig. 32.

Dimensions. 3 × 2½ m.m.

Diagnosis. Shape irregular, outerside convex, innerside flat.
Dorsal rim low and curved ventral deeply carinate, posterior rim rounded, frontal rim with blunt rostrum, prominent antirostrum with notch below.
Sulcus opens widely on frontal rim, ostium wide and curved, cauda narrower with upward inclination.

Remarks. Differing slightly regarding the posterior rim, this otolith agrees in every other particular with that described by SCHUBERT (1) from the pliocene and miocene of New Guinea. I have no hesitation in referring it to *Otolithus* (Scopelus) *papuensis* SCHUBERT.

Occurrence. Single example.
Robulinaklei, Aloeë Groh. (Peusangan).

Age. Upper tertiary (Neogene).

Otolithus (Solea) glaber KOKEN. Plate II, fig. 33.

Dimensions. 2 × 1½ m.m.

Diagnosis. Shape ovate, bi-convex. Dorsal and ventral rim curved, posterior rim angular, frontal rim rounded with indentation at junction with dorsal rim.
Sulcus simple, ovate, oblique, termination well away from posterior rim.

(1) R. SCHUBERT, Verhandl. der K. K. Geol. Rchs.-Anst. p. 318, Wien 1918.

Remarks. Described by KOKEN ([1]) from the oligocene of North America, the sulcus being a little more produced forwardly than in the example now described. The contour of the otolith corresponds however and the position and inclination of the sulcus are in both cases the same, also the distance of its termination from the posterior rim.

Occurrence. Single example.
Rotalia-zone, Aloeë Oeleuë Keubeuë (Peusangan).

Age. Upper tertiary, (Neogene).

Otolithus (Solea) angulatus s.p. n. Plate II. Fig. 34.

Dimensions. 2 × 2 m.m.

Diagnosis. Shape circular, outer and inner sides flat.
Dorsal rim domed, ventral rim slightly curved, posterior rim rounded, frontal rim perpendicular with rostrum, no rostrum, no antirostrum or notch.
Sulcus circular with broad raised ridge and groove surrounding it.

Remarks. This example approaches an otolith described by PIERAGNOLI ([2]) from the miocene and pliocene of Orciano, Pisa, Italy, and ascribed by her to *Solea Kokeni* BASS & SCHUB. but in the species now described the posterior rim is more rounded and the rostrum lower and more prominent. It is a new species showing considerable likeness to some otoliths of the recent Soleidae. The high front and low prominent rostrum are well marked features, and I have called this species *Otolithus* (Solea) *angulatus sp. n.*

Occurrence. Single example.
Rotalia-zone, Al. Bintanghoe (Peusangan).

Age. Upper tertiary, (Neogen).

Otolithus (Cepola) oriens sp. n. Plate II Fig. 35.

Dimensions. 3 × 1¾ m.m.

(1) E. KOKEN, Zeit. d. Deut. Geol. Ges. XL, p. 274 Berlin 1888.
(2) L. PIERAGNOLI, Riv. Ital. di Paleont. Anno XXV p. 12 Parma 1919.

Diagnosis. Schape roughly ovate, biconvex.

Dorsal rim, high, rhomboidal, ventral rim curved, posterior rim with curved indentation, frontal rim concave, rostrum, no antirostrum or notch.

Sulcus does not reach, frontal or posterior rims.

Ostium and cauda equal.

Remarks. Otoliths of the Cepolidae have been described from the pliocene of Monte Gibio, Italy, by BASSOLI (1) and the pliocene of Orciano, by PIERAGNOLI (2), both of these being very similar to those of the living species *Cepola rubescens.*

The species now described differs from all these forms in the high squared dome and in the concave indentation of the posterior rim. It is a new species and I have named it *Otolithus* (Cepola) *oriens* sp. n.

Occurrence. Single example.

Tufconglomeraat-zone, Anak Oeweuë Gadjah (Peusangan).

Age. Upper tertiary, (Neogene).

Otolithus (Pleuronectes) elongatus sp. n. Plate II, Fig. 36.

Dimensions. 4 × 2 m.m.

Diagnosis. Shape ovate, bi-convex.

Dorsal and ventral rims curved meeting in front and posteriorly, the angles rounded. Rostrum, blunt, no antirostrum or notch. Sulcus undivided, oblique, open on frontal rim, terminating near the middle of the otolith and far from the posterior end.

Remarks. Contour of otolith is very similar to otolith described by BASSOLI (3) from the pliocene of Monte Gibio as *O.* (Pleuronectidarum) *acuminatus* KOKEN, but differing essentially from that species as does that now described in the extreme prolongation of the posterior end. The otoliths referred to by KOKEN and BASSOLI have an ovate enclosed sulcus in both cases, but in the species described the sulcus is more oblique and opens on the frontal rim. Differing in this important feature this is undoubtedly a new species which I have named *Otolithus* (Pleuronectidarum) *elongatus* sp. n.

(1) G. G. BASSOLI, Riv. Ital. di Paleont. Anno XII Tav. 11 fig. 43 Perugia 1906.
(2) L. PIERAGNOLI, Riv. Ital. di Paleont. Anno XXV Fasc. l. 11, Parma 1919.
(3) G. G. BASSOLI, Riv. Ital. di Paleont. Anno XIII, Tav. 11, Perugia 1906.

Occurrence. Rare.
Hoofdfossiel-zone, Aloeë Geureugah (Nisam).

Age. Upper tertiary, (Neogen).

Otolithus (Arius) tenuis sp. n. Plate II. Fig. 37.

Dimensions. 5 × 3½ m.m.

Diagnosis. Shape conchoidal, biconvex, outerside smooth.
Dorsal rim highly domed, sloping posteriorly to angle of juncture with the ventral rim, ventral rim curved, frontal rim concave with ventral projection or beak.

Remarks. In this genus the lapillus is the principal otolith.
Resembling an otolith described by E. T. Newton (1) from the upper eocene of Barton as Arius sp. C. the species now described is rather more oval in shape and differs posteriorly by reason of the angle between the postero-dorsal and the ventral rims. In flatness it is similar to *O.* (Arius) (2) *germanicus* Koken, from the oligocene of Lattorf and Sollingen and also shows the peripheral and radial lines of this species, differing however in the concave front and beak, and posterior angle. It is a new species which I have named *Otolithus* (Arius) *tenuis* sp. n.

Occurrence. Single example.
Hoofdfossiel-zone, Al. Geureugah (Nisam).

Age. Upper tertiary (Neogene).

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(1) E. T. Newton, Proc. Zool. Soc. of London, p. 201, Ap. 1889.
(2) E. Koken, Zeit. d. Deut. Geol. Ges Band. XLIII, Taf. VI, Berlin 1891.

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